DOCUMENT RESUME

ED 089 984 SE 017 511

AUTHOR Altieri, Donald; Becht, Paul
TITLE Individualization of Instruction: High School Chemistry - A Case Study.
INSTITUTION Florida Educational Research and Development Council, Gainesville.
PUB DATE Jan 74
NOTE 40p.

EDRS PRICE MF-$0.75 HC-$1.85 PLUS POSTAGE
DESCRIPTORS Case Studies; *Chemistry; Curriculum; Educational Research; Evaluation; *Individualized Instruction; *Program Descriptions; *Secondary School Science; Student Attitudes
IDENTIFIERS Research Reports

ABSTRACT

This publication contains information on the individualization of instruction in high school chemistry in the form of a case study. The subject of the case study is the P. K. Yonge Laboratory School of the University of Florida, Gainesville. The instructional model, however, was also field-tested in 18 schools during 1971-72 and 1972-73. The publication is divided into five sections: foreword, history, individualized chemistry program, how to begin individualizing instruction, and individualized chemistry field study and results. In the foreword, individualized instruction is defined as not consisting of study packets, audio-tutorial programs, self-pacing, systems approach, and instructional or behavioral objectives. A four-part operational definition of individualized instruction as exemplified in the reported chemistry program is then presented. (PEB)

ED 089984

INDIVIDUALIZATION OF INSTRUCTION HIGH SCHOOL CHEMISTRY– A CASE STUDY

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RESEARCH AND DEVELOPMENT COUNCIL

SE 017 511

INDIVIDUALIZATION OF INSTRUCTION HIGH SCHOOL CHEMISTRY— A CASE STUDY

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Sponsored by

The Florida Educational Research and
Development Council
University of Florida

January, 1974

MAR 2 1 1974

FOREWORD

How do you individualize instruction? Many plans for individualization have been printed in the last ten years—some have been thoroughly field-tested, others have not. The statements made about individualization in this FERDC Bulletin represent a great deal of thinking, planning, work, and field-testing. The thinking, planning and work by the authors began in the 1969-70 school year, and continued to the present 1973-74 school year. Through the cooperation (and thinking and work) of FERDC chemistry teachers, the model was field-tested in 18 schools during 1971-72 and 1972-73. What had worked at the P. K. Yonge Laboratory School also worked in other schools.

Altieri and Becht present a model for all teachers interested in individualizing instruction whatever the content area may be. There are step-by-step practical, tested suggestions offered which could help a teacher—or team of teachers—develop his own individualized program.

FERDC is proud to present the results of one of the most successful programs we have had the good fortune to sponsor.

January, 1974

Wm. F. Breivogel,
Executive Secretary

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INDIVIDUALIZATION OF INSTRUCTION HIGH SCHOOL CHEMISTRY– A CASE STUDY

Individualized Instruction means many things to many people. Our definition of Individualized Instruction is *not*:

Study packets
Audio-tutorial programs
Self-pacing
Systems approach
Instructional or behavioral objectives

But rather, Individualized Instruction is:

1. Identifying the key concepts to be studied either by the instructor or jointly by the instructor and student.
2. Knowing the student well enough to determine his cognitive style (i.e., how he learns) and his affective style (i.e., his attitude toward learning).
3. Planning with the student, those activities which will cause him to achieve the objectives of the course or program.
4. Evaluating the student in terms of his success or ability to meet the stated objectives rather than some mythical set of group norms.

This is but one of the many definitions.

Individualized Programs have been with us for many years and each program has had its own meaning of individualizing. Aristotle individualized by involving his small group of students in what they were to learn. The Parker Schools in Quincy, Massachusetts, and the Cook County Normal School in Chicago, were centered around the child and his interests during the 1880's and 189[illegible] In the early 20th Century, John Dewey said to bring education to the child, not the child to education. To individualize in those days meant to try to meet the educational needs of the students. But these needs were most often defined by people who had little or no understanding of the many needs associated with the various developmental levels and cognitive styles of students. Thus programs that were designed met the needs of only a few, leaving the rest to fair for themselves. From the success, or lack of success of these programs, educators began to learn about the varied educational needs found in each classroom.

Many plans were designed to "individualize" the curriculum and break

the academic lockstep such as project methods, homogeneous groupings, ability groupings, and integrated programs. Audio-visual aids, libraries, guidance departments, lunches, recreation, transportation and work experience programs were added to school systems to better take care of student needs. Extensive testing programs were incorporated in school systems to aid the process of assessing individual abilities and setting standards of school achievement for various age and grade groups.

But all these attempts at individualization fell short of complete success. The totally individualized classroom requires much more support and knowledge than is available even today. We still are groping for a basic understanding of student learning behaviors and the techniques for determining what the behaviors are and what they mean. Many programs have recently come out using a multi-media approach toward meeting the varied needs of students. These programs along with team teaching, open classrooms and learning modules are a step in the right direction toward a truly individualized program.

An example of an attempt at individualization is *Individualized Chemistry*, a self-paced, individualized approach to teaching high school chemistry. This program, developed at P. K. Yonge Laboratory School, University of Florida, utilizes many of the approaches discussed above along with some new techniques to try to meet the educational as well as the practical needs of a student wishing to learn about chemistry. This program was developed in the classroom with students providing formative evaluation to the materials.

HISTORY

The first major step in the development of an individualized program in chemistry occurred during the summer, 1969. Six graduate students involved in a clinical teaching experience at P. K. Yonge, designed and implemented an individualized program in chemistry. Students from the Gainesville area volunteered for the program. The teachers wanted to put into practice the ideas that they had read relative to individualizing instruction. They identified the concepts to be taught, planned the usage of several strategies for instruction, procured a wide variety of materials, and developed an elaborate procedure for evaluating student progress.

During the clinical teaching experience, video tapes were made of the teachers and students. Four systematic observation instruments; Teacher Practice Observation Record (TPOR), Reciprocal Categories System (RCS), Florida Taxonomy of Cognitive Behavior (FTCB), and Taxonomy of Image Provoking Behavior (TIPB), were used to evaluate the actions of the teachers and students. Some of the resulting research findings were used as a basis for the design of the Individualized Chemistry program. For

example, it was found that problem sessions, i.e., where the teacher went over either homework or class problems, elicited a rather low level cognitive behavior on the part of the students. Based on this research finding, formal homework and problem sessions were not included as a strategy in our Individualized Chemistry Program. Instead, students are encouraged to work the problems assigned, check the answers themselves and then see the teacher about those problems which they did not understand. The instruments also indicated that straight lecture produced a rather low level of cognitive behavior. Therefore, the formal lecture as such was deemphasized in our chemistry program. It was replaced with individual and small group sessions with an occasional 'mini' lecture when a large number of students wanted to know something about the same topic.

Many ideas and strategies were tested during the clinical teaching experience such as team teaching and team planning, extensive use of media, alternative laboratory experiences for a given concept, use of oral quizzes, student self evaluation and project work.

This program provided the catalyst for the development of the Individualized Chemistry Program at P. K. Yonge.

In the fall of 1969, it was decided to begin to design and implement an individualized program in chemistry as part of the science program at P. K. Yonge. The authors began designing by night and teaching by day. (We don't recommend this procedure at all!) It would have been better to wait a year and do some careful planning, but the frustration level with the teaching of traditional chemistry was too high to combat. Therefore, we jumped in with both feet.

During the year, a graduate student in chemistry education became interested in what we were doing. She wanted to get involved in the project. We were interested in feedback from the students relative to the effectiveness of the program to that point. This student designed and administered a questionnaire to the students in the program and tallied the results. This became our first formative evaluation and it was used to modify and strengthen the program. A modified form of this questionnaire was used in subsequent field testing of the Individualized Chemistry Program (Figure 1).

Major emphasis of the project during the first year included identifying content, developing a management system which included a system for student evaluation, and coordinating laboratory activities.

Based on the feedback from the student questionnaires, the program was modified and updated during the summer of 1970. Because of growing interest in individualizing instruction, it was decided to begin a limited field testing operation. Therefore, during the 1970-71 school year, the authors not only taught the Individualized Chemistry at P. K. Yonge, but produced

materials for use in six other schools. Major emphasis during the second year included refining the program, decreasing the amount of basic content and making more of it optional and/or enrichment, developing quiz questions and teacher manuals, and designing a research study aimed at testing the effectiveness of the program.

In the summer of 1971, further refining and modifying took place as well as getting ready to field test the program in a large number of schools. Feedback from these schools during the 1971-72 school year provided the data for the most recent revision of the program.

The revised materials were then made available to schools during the 1972-73 school year.

At the present time (summer, 1973), the materials are being refined in preparation for large scale publication.

Figure 1: Individualized Chemistry Questionnaire

INDIVIDUALIZED CHEMISTRY QUESTIONNAIRE

PART A:

Answer Part A only on the answer sheet provided. For each of the following questions indicate your answer on the answer sheet corresponding to the question number being answered. Use the following scale to code the answer sheet:

1 = Strongly Agree
2 = Agree
3 = Don't Know
4 = Disagree
5 = Strongly Disagree

This is not a timed test. Take your time and when finished turn in both the questionnaire and the answer sheet to your teacher.

1. Performing experiments in class helps me understand the chemical concepts I have been studying.
2. The results of my experiments make sense.
3. I have enough mathematical background to do the problems assigned.

4. I see a new value in studying chemistry I did not see before.
5. The pressure of other classes (having certain assignments ready at certain times) cause me to "put off" doing chemistry.
6. I am satisfied with my progress in this class.
7. I plan the work I expect to cover in a week or contracted period of time.
8. I feel that I can ask questions at any time.
9. I *ask* questions when I don't understand.
10. The tests are fair.
11. I look back every week (or some other period of time) and evaluate my progress.
12. I think the tests really measure what I know.
13. Answering the questions on the guide sheets really helps me.
14. I chose to take this course.
15. "Individualized Study" is the best way to study chemistry.
16. I am able to see a *direction* in what I am studying in Chemistry.
17. I *understand* and can *explain* the concepts I have studied in Chemistry.
18. As a result of this course, I now know how some of the great discoveries in science were made.
19. As a result of this course, I plan to major in science or math in college.
20. I feel confident that I can handle this subject on an "individual study" basis.
21. I enjoy discussing this class at home.
22. I feel free to discuss chemistry (problems, experiments, etc.) with my classmates.
23. I see relationships between what I am learning in Chemistry and what I have learned in other science courses.
24. I am able to read and understand the textbooks I am using.
25. From what I have experienced in science, I think a scientist can be creative.
26. I find science exciting.

PART B:

Please answer the following in the space provided:

1. What unit and guide sheet are you working on at this time?

2. If other classes pressure you to put off chemistry, what can be done about this problem?

3. How do you plan your work week for chemistry?

4. Has this course been helpful to you? In what way?

5. What did you expect from this course when you signed up for it? Are you getting what you expected?

6. What do you find most rewarding in this class?

7. What do you find least rewarding in this class?

8. How would you revise the set-up of this course to make it more rewarding for you?

9. Besides your tests and lab equipment, what other "aids" available in your classroom have you used?

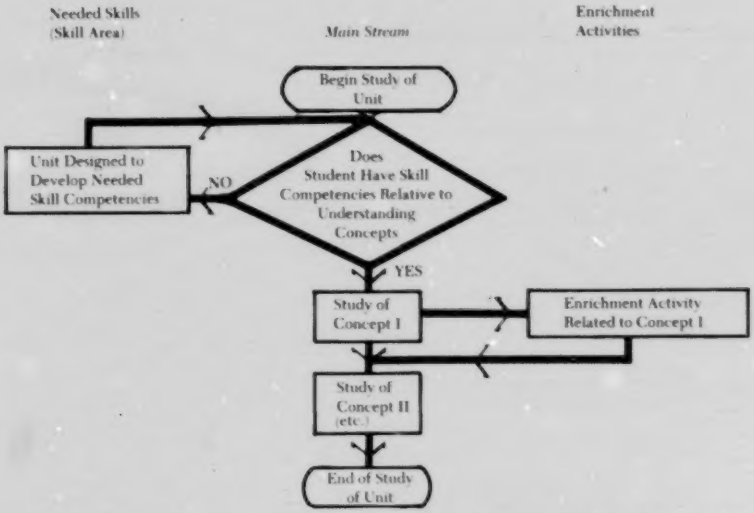
10. Please make any additional comments or suggestions which would make the class a better "learning situation."

INDIVIDUALIZED CHEMISTRY PROGRAM

Most schools have a set of general goals which represents the philosophy of the school and provides the framework for the program of instruction. The chemistry program to be described is based upon and consistent with the following general goals for students at P. K. Yonge:

1. That each student develop increasingly positive perceptions of himself.
2. That each student become an effective life-long learner.
3. That each student accept increasing responsibility for his own behavior and learning.
4. That each student develop those skills and attitudes necessary for effective group living and democratic interaction.
5. That each student learn to adapt to change and positively effect change.
6. That each student find real meaning for his life.

Figure 2: Stylized Model for Individualizing Instruction



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These goals were used as guidelines in developing the program.

In order to develop and maintain successful programs of science, there must exist a clear relationship among the stated goals of a school, the instructional objectives of a given program, and the activities utilized to implement that program. This idea was kept in mind as this particular program was developed.

The program itself is patterned after a model of instruction developed at P. K. Yonge Laboratory School which is used in science courses at our school. The model basically illustrates that in an individualized program there are ideas with which all students should come in contact, there are ideas that are 'nice to know', and there are skills necessary for the understanding of the basic ideas (Figure 2).

Once the model was established, the next step was to organize the content. Rather than scrapping the existing Chemistry program, those parts that were successful were pulled from it. (The program is organized into seven units—Units I and II are basic, Units III through VII are optional) (See Figure 3)

Figure 3: Organization of Units for Individualized Chemistry

Unit I: Introduction to Chemistry
- Guide Sheet 1: Man and Science
- Guide Sheet 2: Sand and Mortar of Chemistry

Unit II: The Inside Story of Chemistry
- Guide Sheet 1: Mendeleev's Brainchild
- Guide Sheet 2: The Devious Mole
- Guide Sheet 3: A Matter of Phases

Unit III: Microchemistry
- Guide Sheet 1: Nuclear Chemistry
- Guide Sheet 2: Biochemistry

Unit IV: Chemical Reactions and Energetics
- Guide Sheet 1: Energy Effects and Rates of Reactions
- Guide Sheet 2: Equilibrium in Chemical Reactions
- Guide Sheet 3: Acids, Bases and Oxidation-reduction Reactions

Unit V: Atomic and Molecular Theory
- Guide Sheet 1: The Atom
- Guide Sheet 2: Quanta and Electron Orbitals
- Guide Sheet 3: Bonding

Unit VI: Biochemistry

Guide Sheet 1: Carbon and His Buddies
Guide Sheet 2: The Chemistry of Life

Unit VII: Nuclear Chemistry

Guide Sheet 1: Properties of the Nucleus
Guide Sheet 2: Natural Radioactivity and Fission
Guide Sheet 3: Fusion and Stellar Element Formation

Each of these units was further divided into a basic instructional unit called a "Guide Sheet" (Figure 4). Each guide sheet consists of a series of questions which are designed to help the student clarify and understand the concept or concepts related to that guide sheet. In addition to the questions, there were problems to work and laboratory experiments to be performed. Each guide sheet was developed around a general instructional objective while each lab was developed on the basis of its ability to produce a certain behavior. An objective was stated for each lab. An all-out effort was made to correlate the problems, questions and laboratories so that the student would begin to formulate and acquire the concepts involved. The questions were worded in such a manner that the student had to use more than one source of information. Students need to use more than a single source or text in order to become aware of different ways of expressing ideas and to learn not to rely on any one source as providing the "whole truth". The program is highly laboratory oriented. There are 54 laboratories which are part of the main stream and 10 option or enrichment laboratories (Figure 5).

Figure 4: Sample Guide Sheet

UNIT I: INTRODUCTION TO CHEMISTRY

Guide Sheet 1: Man and Science

Objective:

You are to develop an awareness of the role of the scientist in society.

GUIDE QUESTIONS:

1. Without consulting any source of information, list what you think are some characteristics of a scientist.

2. Do some reading about alchemy and the alchemists and answer the following questions:

A. What was alchemy?
B. What was the alchemist trying to prove?
C. What influence did alchemy have on modern science?

3. Are scientists today any different than they were 100 or 200 years ago? Explain.
4. Are scientists today more 'in tune' with the world than they were in previous times? Explain.
5. Can man be a scientist and be responsive to the society at the same time? In what ways?
6. What is the difference between science and technology?
7. What are some of the problems supposedly created by technology?
8. Who has the responsibility for finding solutions to the major technological problems of today?
9. The following is a list of chemical names used in the past. Write the modern names for each one listed.

A. Acid of Salt
B. Phlogiston
C. Dephlogisticated Acid of Salt
D. Aqua Fortis
E. Aqua Regia
F. Oil of Vitriol
G. Cinnabar
H. Mercurial Sublimate

PROBLEMS:

No problems assigned

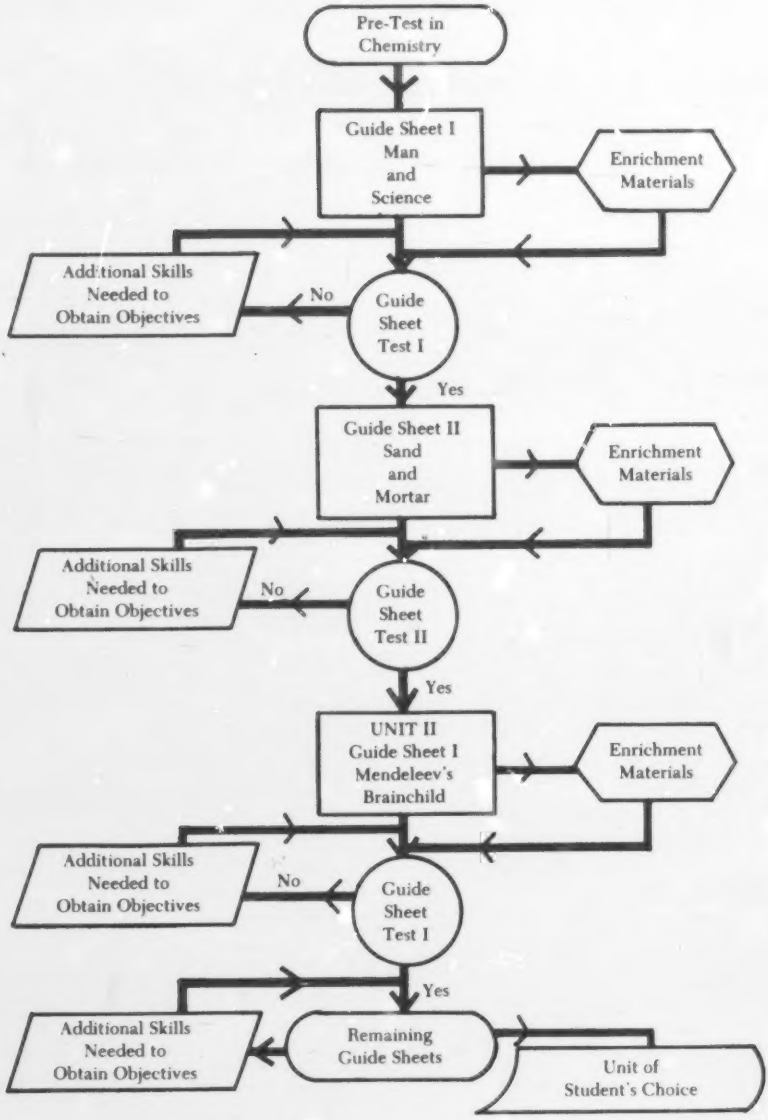
LABS

#1 & #2

REFERENCES

General Chemistry books
Recent Periodicals

Figure 5: Flow Diagram of Units I and II



A contract for time was developed and is used by the students. Students want freedom but at the same time they need some structure. The contract for time is a compromise (Figure 6). It was found that during the pilot study of this program students tended to put off their chemistry in order to do more pressing work in other subjects. This caused many students to lag

Figure 6: Individualized Chemistry Contract

INDIVIDUALIZED CHEMISTRY CONTRACT

NAME: _____ Date: _____

Unit Number: _____ Guide Sheet Number: _____

I will endeavor to complete this guide sheet by this deadline date: _____. I understand that if I do complete the material on or before the deadline, I will be given 20 points additional credit for the guidesheet. After one week (a grace period—5 school days) beyond the deadline, I will loose 5 points per day. During the grace period, no extra credit will be given. Here is how I will be scored:

Item	*Max ← to → Min Points*
Lab	10 or 5 or *0
Guide Questions	5 - 0
Problems	5 - 0
Quizzes	20 - 0

*option to later score 5 points

Signed: _____

Witnessed: _____ Chemistry Instructor

Date: _____

cc: To the Chemistry Instructor

behind their potential work rate. It was decided that many students, probably because of the nature of our educational system, were not ready to be totally independent and actually requested that some means of pressure be exerted to help them keep up in the course. The contract idea was thought to be the most fair and realistic solution to the problem. When the contract comes due, the student still has a one-week grace period. By the end of that grace period, he must take the quiz or evaluation designed for that Guide Sheet or be penalized. If he does not attain minimum expectations for that Guide Sheet he is recycled with a specific study plan aimed at helping him understand the ideas which were not clear to him. Each student should attain some basic level of understanding of each of the concepts presented before proceeding. The objective is for the student to arrive at the end of the program with concepts that are relatively clear and distinct in his mind.

Before the student can take the quiz associated with the Guide Sheet, he must have all of this material checked and reviewed by the teacher. Specifically, the teacher checks the guide questions and the labs; the student checks his own problems noting the ones he missed. The teacher and student sit down and go over all of this together clarifying those points that need it. At this point, the student takes the quiz.

The system of evaluation consists of a bank of quiz questions, each of which is on a "key-sort" card. The student is given the deck and he selects however many questions as he needs to obtain 20 points. Each question has been labelled according to Bloom's Taxonomy of Cognition, each level given a point weight, i.e., Level 1 worth 1 point, Level 2 worth 2 points, etc.

It should be interjected at this point that if one is committed to a personalized, individualized program, then traditional class standards no longer are valid. Therefore, it does not make any difference if one student does five questions and another does 10 or that they do not do the same questions. What is important is that we teachers try to provide instructional settings that are nonthreatening and that tend to enhance the individual's self concept. We have tried to have our students see the quiz as a small part of the total program and that it is a means of helping them and us to know if they can apply what they have learned.

Units I and II contain a large number of one level and two level questions, but also contain questions from the three, four, five and six levels. In Unit III the number of one and two level questions is reduced and the number of three level questions is increased; the same procedure is followed in Unit IV with the over-all level of questions being higher than Unit III.

Students entering chemistry are really no different from students entering a foreign language class. Therefore, there is a need to learn the basic facts, terminology and vocabulary in order to communicate. Once this has

been established, the student can go on to build and acquire concepts and ideas. In terms of Bloom's taxonomy, chemistry is seen at the application level and attempts have been made to design the cognitive part of the program in such a way that the student will be operating cognitively at that level at the end of the program.

Record keeping for this type of program is important and could be very time consuming. One of the teachers testing the program suggested using a card for each student. The student keeps track of what he has done and this helps to keep him aware of where he is in the program. Another teacher developed this idea into a student folder. A file folder is set up for each student. The student keeps the folder updated and is responsible for keeping track of his progress. The folder consists of the following to be used for each guide sheet: 1) Contract (Figure 6); 2) Student Inventory Sheet (Figure 7); 3) Scoring Sheet Form (Figure 8); 4) Individualized Chemistry Progress Report (Figure 9). Students were found to keep very accurate records. At the end of each marking period, the student records his progress for that period and the evaluation is sent home to his parents (Figure 10). No longer are statements such as these heard: "What grade am I getting this time?" or "I don't understand why I got a C."

At this time formal affective objectives have not been stated other than in the general objectives, but there are many informal ways for developing positive attitudes toward science, learning in general, and the importance of worthiness of each individual. This is demonstrated by the responsibilities given to the student in this type of program. First, recognizing that each person is unique and his patterns of learning are different, he is encouraged to proceed with his study of chemistry at a rate commensurate with his background and former knowledge. The student keeps his own records and has some choice over the kinds of quiz questions which he takes. He is encouraged to give feedback in terms of which laboratories helped him the most and those which helped him the least in understanding or learning a particular concept or idea. The student is given the freedom to decide each day how he is to use his time. Does he do a lab, work problems, ask questions, or just goof off?

This type of program also helps to keep the student thinking positively about science and school in general. He does not get uptight nor do the teachers if he is absent because of sickness, sports, or other student activities. The student knows what is expected of him and can proceed accordingly. No longer does the student ask: "What have I missed?" or "What do I have to make up?" or "When can I come in to see you about what I missed in class?".

Personal contact with the students in the class has increased. Most of the teacher's time in class is spent in a one-to-one ratio or small group interac-

tion with students. The teacher may go over the same idea many times but he goes over it when the student is ready rather than when the teacher thought all students were ready.

These factors formulate the basis of the Individualized Chemistry program at P. K. Yonge Laboratory School. The program will constantly be undergoing change and modification. If educators are to provide the best education for students, then any program which is to have survival value must be of a dynamic nature.

Figure 7: Student Inventory and Evaluation Sheet

STUDENT INVENTORY AND EVALUATION

Guide Ques.			Problems			Laboratories			Totals	
No.	Pts.	Compl. Date	No.	Pts.	Compl. Date	No.	Pts.	Compl. Date	Items	Points
									Guide Questions	
									Problems	
									Laboratories	
									Extra Credit	
									Oral Quiz	
									Written Quiz	
									Grand Total	
									Max. Possible Score	
									Calculate Here:	
									Percentage Score	
									Letter Grade	
Total Points			Total Points			Total Points			Instructor's Initials	

Student's Name _____ Unit _____ Guide Sheet _____

Instructor _____ Deadline _____

Figure 8: Individualized Chemistry Scoring Sheet

INDIVIDUALIZED CHEMISTRY SCORING SHEET

FOR UNITS I & II

UNIT I: INTRODUCTION TO CHEMISTRY

Guide Sheet I: Man and Science	
Guide Questions	5
Quizzes	20
Labs	20
Maximum points	45
Guide Sheet II: The Sand and Mortar of Chemistry	
Guide Questions	5
Problems	5
Quizzes	40
Labs	20
Maximum Points	70
Total Points Unit I:	115

A	B	C
90% on Quizzes and Labs and above 104 pts.	80% on Quizzes and Labs and above 92 pts.	70% on Quizzes and Labs and above 81 pts.

UNIT II: THE INSIDE STORY OF CHEMISTRY

Guide Sheet I: Mendeleev's Brainchild	
Guide Questions	5
Problems	5
Quizzes	40
Labs	20
Maximum Points	70
Guide Sheet II: The Devious Mole	
Guide Questions	5
Problems	5
Quizzes	40
Labs	40
Maximum Points	90
Guide Sheet III: A Matter of Phases	
Guide Questions	5
Problems	5
Quizzes	40
Labs	40
Maximum Points	90
Total Points Unit II	250

A	B	C
90% on Quizzes and Labs and above 225 pts.	80% on Quizzes and Labs and above 200 pts.	70% on Quizzes and Labs and above 175 pts.

Requirements for Chemistry Credit

Complete Units I & II and any one other unit at a 70% level of completion.

Figure 9: Individualized Chemistry Progress Report

INDIVIDUALIZED CHEMISTRY PROGRESS REPORT

NAME _____ PERIOD _____

GRADE _____ INSTRUCTOR _____

Unit I: Introduction to Chemistry

Letter Grade

Guide Sheet 1: Man and Science _____
Guide Sheet 2: Sand and Mortar of Chemistry _____
Unit Grade _____

Unit II: The Inside Story of Chemistry
Guide Sheet 1: Mendeleev's Brainchild _____
Guide Sheet 2: The Devious Mole _____
Guide Sheet 3: A Matter of Phases _____
Unit Grade _____

Unit III: Microchemistry
Guide Sheet 1: Nuclear Chemistry _____
Guide Sheet 2: Biochemistry _____
Unit Grade _____

Unit IV: Chemical Reactions and Energetics
Guide Sheet 1: Energy Effects and Rates of Reactions _____
Guide Sheet 2: Equilibrium in Chemical Reactions _____
Guide Sheet 3: Acids, Bases and Oxidation-reduction Reactions _____
Unit Grade _____

Unit V: Atomic and Molecular Theory
Guide Sheet 1: The Atom _____
Guide Sheet 2: Quanta and Electron Orbitals _____
Guide Sheet 3: Bonding _____
Unit Grade _____

Unit VI: Biochemistry
Guide Sheet 1: Carbon and His Buddies _____
Guide Sheet 2: The Chemistry of Life _____
Unit Grade _____

Unit VII: Nuclear Chemistry
Guide Sheet 1: Properties of the Nucleus _____
Guide Sheet 2: Natural Radioactivity and Fission _____
Guide Sheet 3: Fusion and Stellar Element Formation
_____
Unit Grade _____

Figure 10: Individualized Chemistry Progress Report for Parents

Date _____ P. K. Yonge Laboratory School

INDIVIDUALIZED CHEMISTRY PROGRESS REPORT

Name _____ Grade _____

Advisory Group Leader _____ Teacher _____

This year the Chemistry Class is involved in continuing a tested concept of teaching—individualization. In other words, the student works at his own rate using the teacher as a resource person. The student is given "Guide Sheets" to assist him in attaining this goal—the use and understanding of the basic concepts in chemistry.

The course is divided into seven units: I. Introduction to Chemistry, II. The Inside Story of Chemistry, III. Microchemistry, IV. Chemical Reactions and Energetics, V. Atomic and Molecular Theory, VI. Biochemistry, VII. Nuclear Chemistry. These seven units are broken into a series of guide sheets which assign specific tasks to the students. As a student completes the tasks on the guide sheet, he becomes qualified to take an exam covering the material on the guide sheet. The student is given a specified number of points on completion of the guide sheet. When all the guide sheets for a unit have been completed, the student will receive a letter grade for the unit. No letter grade will be given to a student until the unit is completed. The reason this procedure was adopted was to allow students to work at

their own pace toward completion of the guide sheets and units. This means that most students will be at different stages in their course work and there will be no way to fairly evaluate the student with respect to his progress and the rest of the class. Therefore, no letter grade will appear on the report card until a unit is completed. Only "S", "U", or "I" will be given indicating satisfactory, unsatisfactory, or incomplete progress in the course.

In order for the student to receive credit in the course, he must satisfactorily complete Units I and II, and any one other unit or an equivalent unit as decided by the student and teacher.

So that you, the parent, may be aware of your son's/daughter's progress, a dittoed sheet indicating units completed will be sent home at the end of each grading period.

I.

Unit I: Introduction to Chemistry	COMPLETED
Guide Sheet 1: Man and Science	_____
Guide Sheet 2: Sand and Mortar of Chemistry	_____

II.

Unit II: The Inside Story of Chemistry	
Guide Sheet 1: Mendeleev's Brainchild	_____
Guide Sheet 2: The Devious Mole	_____
Guide Sheet 3: A Matter of Phases	_____

HOW TO BEGIN INDIVIDUALIZING INSTRUCTION

Step 1. *Formulation of a Working Definition* or: *Mental Model of Individualizing Instruction.*

It would be extremely helpful if the teacher formulates in his or her own mind some model or concept of the process of individualizing instruction. In the case of the Individualized Chemistry Program, a model was developed which formed the basis for the development of the program. All ideas and/or strategies were tested against the model for consistency before being included in the program.

We in education have been accused, and justly so, for the gap between our theory and our practice. If you construct a model and design strategies and practices consistent with that model then you have eliminated one of the major criticisms of education and your program will have a solid foundation.

Step 2. *Testing of Your Model*

a. *Talk to Colleagues.*
Discuss your ideas with your colleagues. How does it sound to them?

b. *Talk to Your Department Chairman.*
Is he or she interested? What kind of feedback did you receive?

c. *Go to Meetings Where the Topic is Being Discussed or Presented.*

d. *Read Current Literature.*
What does it have to say?

e. *Visit Schools Where the Process is in Operation.*
What did you learn?

f. *Attend Workshops Where Hands-On Experience is Provided.*

You may be able to do all of the above or very few of the above. Certainly it would be to your advantage to participate in as many of the above activities as possible. As you participate in each of the activities, you should constantly be testing your model against those being presented. This should result in clarification and/or modification of your model.

In reality, you are not ready to move ahead until you can clearly state your model or a working definition. A word of caution is necessary. We are not implying that your model be fault free at this point or in any way static, but it should be basically stable.

If your model is pretty stable, then you are ready for the next step.

Step 3. *Stating Goals and Objectives*

It is important that you state your goals and objectives for the program. These are general and instructional objectives, not specific performance objectives. These will help you to clarify your model and help you communicate your ideas to others. Up to now, you have been operating as an individual entity, but as you begin to seek resources, you will be interacting with others and therefore you must be able to clearly state what it is that you wish to do and how you plan to do it.

Step 4. *Seeking Administrative Clearance*

The beginning point for administrative clearance will be different for each person. The teacher in a department should begin with the department chairman or if no chairman, the curriculum leader of the school which, in most cases, is the principal.

No matter how your system works, the important point to remember is to keep the parties informed who need to be informed. This is very crucial in the development stage of a new program. Nothing can do you more harm than for the curriculum leader's or department chairman's not being knowledgeable about something being developed in his school or department. These people are there to help you and they can't help you unless they know what is going on.

Here is a list of questions which may be fired at you. You may not be able to answer all of them, but you ought to at least be ready for the questions.

a. *How much will it cost?*
Software—books, filmstrips, tapes, instructional modules, etc.
Media/Multitext?

b. *Who is going to do it?*
One teacher or more? Team teaching/team planning?

c. *How much time will be involved?*
Preparation/workshop, etc.
Teaching

d. *How will it affect scheduling?*
Number of students per class; Lab Time?

e. *Are lab assistants and/or paraprofessionals needed?*

f. *Are resource people available to help?*

g. *How does it affect students?*
Structure—Open or closed / Freedom?
Self pacing
Evaluation—Pass/Fail / Grades?
Prerequisites?

Step 5. *Program Planning*

Once you have administrative approval then the next step is to decide whether to use someone else's program either in total or part or to develop your own.

There is a tendency by people in education to 'discover the wheel' a million times over. Teachers tend to want to do their own thing, and in general, this is a healthy and positive attitude. But in the area of individualizing instruction, it would be helpful to make use of already existing materials if they fit and are consistent with your model and goals. It will be difficult enough to implement an individualized program of instruction let alone try to develop materials too, especially at the same time.

Plan a year in advance! Start planning at the beginning of one school year to implement your program the following year. This seems like a long time, but in reality it is not. It will give you time to try some 'mini' units in your regular classes in order to work out some of the bugs and to give you some idea of the time involved and student reaction. You should plan to work at least part of the summer prior to implementation to make sure you have everything ready to go. Once the school begins there just will not be time to do much creative development work. It will take all you can muster to keep your head above water the first year. You will be disheartened, discouraged, frustrated and ready to commit Hari-kari before it is all over. But others have gone before you and the long range rewards will more than justify the problems of the first year. The level of frustration is indirectly proportional to the amount of planning time prior to implementation. The organization of content will depend on one or more of several variables. If some higher authority has not dictated that you teach some fixed body of knowledge, then you have a wider range of alternatives in designing content than if that were the case. Philosophically then you must determine whether or not your program will or will not have a fixed body of knowledge. This will determine to a great extent the nature and direction of your program.

If you work from the idea of a fixed body of knowledge, then you must consider such ideas as: key concepts to which all students should be exposed; concepts that are nice to know but not considered basic; skills that all students should have; attitudes that all students should develop, etc. If you operate on the premise that the program does not have a fixed body of knowledge, then student needs and attitudes become a major focal point for curriculum planning. Development of decision making skills would be a crucial component of this approach to learning.

Selection of materials, media, resources, etc., will be influenced by your content decisions. Look carefully at materials before selecting or purchasing. Most companies will give you a 30-day review period with another

30-day extension. Materials that "look good" at first glance may in fact be inappropriate for your needs. Get reactions from your colleagues and if possible try them on small groups of students.

If you are teaching a science course, you must consider the procedures for setting up laboratory experiences. If your program includes the self-pacing variable then you must take into consideration the need for availability of several different laboratory experiences at any one time. Do you have the room? What kind of system will you use?

Do you plan to have all of your program materials in one room or will your library or learning resource center be involved? Have you planned accordingly with them?

Will you have student assistants or paraprofessionals available to assist you? If you do, then your planning will be different than if you do not have this resource available to you. You may wish to consider the use of students within each class as assistants and helpers, possibly employing some sort of rotational system.

The nature of the process of individualizing instruction of course will be dependent upon your model and your goals and objectives. A truly individualized program involves a number of strategies employed at the appropriate time with an appropriate group of students or an individual student. Individualizing instruction can be viewed as a multidimensional system and therefore will require a multidimensional approach to instruction. If your school utilizes ideas such as modular scheduling, learning resource centers and independent study programs, then you have some valuable resources which can be used in implementing your program. If you are at the other extreme, i.e., one teacher in one classroom trying to individualize instruction on an economical budget, then you have got your work cut out for you. Each teacher must examine where he or she is on the spectrum based on available resources and school cooperation, then determine what can realistically be accomplished in one year. You may identify several variables which you wish to include in your system, but it may not be feasible to attempt to activate all of them the first year. Work with the ideas with which you are most familiar. Develop subsystems, i.e., small components, of your total system rather than tackling the whole bag.

Step 6. *Program IMPLEMENTATION*

Now that you have created a model, determined goals and objectives, and planned the program, you are ready to put the program into action.

Here are some ideas which may help to make your system run smoothly.

a. Keep your curriculum supervisor, principal and/or department chairman informed relative to what you are doing and what kind of progress you are making.

b. Over plan!! Make sure you have considered any contingency which might arise. Remember, Murphy's Law and all its correlaries will be at work. Keep your long range plan in mind as well as your day-to-day planning.
c. Don't be afraid or embarrassed to ask for help. Sometimes we in education are afraid to admit to mistakes or that we do not have all of the answers. It would be disastrous to play that game with this kind of system.
d. Keep parents informed. Have a meeting to explain what you plan to do or at least send home a letter very early in the school year explaining the program.
e. Keep some sort of record relative to your successes and failures. As you think of new ideas or modifications write them down. It's a long time from September to June and you may forget some of the good ideas if you don't write them down.

Step 7. *Program Evaluation*

Evaluation of your program should be an integral part of your total system. There are two kinds of evaluation which will be important to you. The first is called the formative or process evaluation. This means checking on the program as you go and making modifications if necessary. Suppose you start out using a certain subsystem for evaluating students and you find that it is not working. Look at this area closely and make the necessary modifications. The second type of evaluation is called the summative evaluation. This occurs at the end of the year when you step back and look at the program as a whole. At this point you ask what worked and what didn't work; what turned students on and what turned them off; what should be added and what should be deleted!

It will be extremely helpful to you in evaluating your program if you design some *simple* information-gathering tool for both the formative and summative evaluation. The formative instrument could be administered at appropriate times and places during the school year and the summative instrument toward the end of the year. Research findings seem to indicate that you should administer your summative instrument *4 to 6 weeks* prior to the closing of the school year.

Step 8. *Program Revision*

Program revision and program evaluation obviously go hand in hand. Some revisions could occur as a result of your formative evaluations during the school year. Major revisions which would result primarily from your summative evaluation would take more time and could have to take place during the summer months or at times when you are not engaged in teaching. It is realized that in many cases major modifications cannot take

place other than when school is in session, i.e., when you are employed to teach, and if that is the case then you've got your work cut out for you. If you are not and cannot be employed during the summer months, then your progress and modifications to your program will of necessity take more time.

It would be to your advantage at the time you initiate activities relative to seeking commitment for an individualized program that you make clear the need for revision and modification time as well as planning time. Given a year's lead time, someone in your system might be able to find funds to support you at the time of revision. The secret to getting this kind of support lies in your ability to *clearly* state what it is you want to do, how long it will take, and how much it will cost.

If you have read this far, then you probably have some interest in starting your own program of individualized instruction. In summary then, here are some key words to keep in mind as you begin to think seriously about this kind of process.

A. *Commitment*

You, the teacher, must be committed. If you are not—forget it! You must have commitment from those who either supervise you and/or control the purse strings. Make sure this is a clear commitment not only on an educational and philosophical level but also on a dollar-and-cents level. You can't buy many materials with philosophical commitment!

B. *Information*

Keep people informed of what you are doing.

C. *Positiveness*

Be positive and don't get discouraged if things do not go smoothly. You will experience frustrations and have anxieties about what you are doing, but this is true of any curriculum process or change.

D. *Openness*

Be open to suggestions and new ideas which will cause improvement and/or refinements of your program. Look at what others are doing and listen to what others have to say.

E. *Honesty*

Be intellectually honest about what you are doing. *Don't* paint rosy pictures if they do not exist. *Don't* exaggerate the strengths of your program and minimize the weaknesses. "Tell it like it is"!!

Keeping these words in mind as you plan and implement your program will help to keep you from falling into some of the traps that have caused new programs and ideas to flounder and sometimes fail.

INDIVIDUALIZED CHEMISTRY FIELD STUDY AND RESULTS

The Individualized Chemistry program needed support in order for the program to be refined for possible use in Florida schools. In the 1970-71 school year, a grant was received from the Florida Educational Research and Development Council (FERDC) to perform a limited field testing of the program in six Florida High Schools. This field testing was undertaken to obtain formative data to be used in program improvement. Upon completion of this field testing program, an expanded field testing program was initiated to obtain not only formative, but summative data to determine the effectiveness of *Individualized Chemistry* in Florida schools. This field study, with the assistance of FERDC, involved nearly 1,500 students in 22 schools in 18 counties.

Because of the number of participating schools, randomization was possible in the assignment of schools as experimental or control and in the selection of classes within schools where there was more than one class. Schools were grouped into matched pairs, then randomly designated as experimental or control. Sizes varied from the small rural high school with few students in a single chemistry class to the large city high school with as many as 30 students in each of many classes. We assumed these students represented a cross section of the pupil population attending public schools in the state.

Teachers were those who usually teach high school chemistry. Their teaching assignments as experimental or control teachers were determined by the random designation of the school. If the school was selected as an experimental center, then a teacher or teachers within the school undertook the individualized program. Drive-in conferences were held at P. K. Yonge Laboratory School and experimental sites were visited by the specialists responsible for conducting the investigation.

Classes for both the experimental and control aspects of the study were conducted in the chemistry classes normally assigned in the school.

Hypotheses were expressed in NULL FORM. These were:

1. There will be no significant difference between the experimental and control groups with respect to achievement in chemistry.

2. Experimental and control groups will show no significant changes in attitudes toward science (and self).

3. There will be no significant difference between experimental and control group with respect to reading ability.

Instruments used were the ACS-NSTA Chemistry Test, and STEP

Reading Test, and All-Subjects Attitude Scale (Figure 11, 12), and a locally prepared questionnaire for students (refer to Figure 1).

All 1,500 students were given both pre- and post-tests of the All-Subjects Attitude Scale. Then, of the 1,500 students, 607 with matched data were used. Experimental and control groups were assigned in accordance with the Pre-Test/Post Test Control Group, Design No. 4 of the Campbell and Stanley design series

$$R \quad O_1 \times O_2$$
$$R \quad O_3 \times O_4$$

This design has no control for external validity; however, it does control for all sources of internal invalidity. The sources for external invalidity and means of correction used in the study are listed as follows:

1. INTERACTION OF TESTING AND X:
   Corrected for by using equivalent but different tests.
2. INTERACTION OF SELECTION AND X:
   Corrected for by generalizing only for the FERDC schools participating in the program.
3. REACTIVE ARRANGEMENTS: (Hawthorne Effect)
   Corrected for by giving both experimental and control students the same test and using schools where experimentation was not novel.

Results from the data using Analysis of Covariance were:

1. Using the ACS post test as the fixed variable and the ACS pre test and the STEP pre test as the covariate:
   $F_{1,17} = 3.41$ Sig. $(.1)_{1,17} = 3.03$
2. Using the ACS post test as the fixed variable and the ACS pre test and Attitude pre test as the covariate:
   $F_{1,17} = 3.15$ Sig. $(.1)_{1,17} = 3.03$
3. Using the difference in the pre and post test Attitude scores as the fixed variable and the ACS pre test as the covariate:
   $F_{1,18} = 3.67$ Sig. $(.1)_{1,18} = 3.01$

Figure 11: All Subjects Attitude Scale—Pre Test

ATTITUDE TEST

PRE

SERIAL NUMBER_____

There are no right or wrong answers to these questions. People differ in their opinions on them. Just indicate your own opinion by blacking in with a #2 pencil the number on the answer sheet which corresponds most closely with your feelings. Leave no blanks.

1 = Agree, 2 = Disagree

1. No matter what happens, this subject always comes first.
2. I would rather study this subject than eat.
3. I love to study this subject.
4. This subject is of great value.
5. This subject has an irresistible attraction for me.
6. I really enjoy this subject.
7. This subject is profitable to everybody who takes it.
8. This subject develops good reasoning ability.
9. This subject is very practical.
10. Any student who takes this subject is bound to be benefited.
11. This subject teaches me to be accurate.
12. This subject is a universal subject.
13. This subject is a good subject.
14. All of our great men studied this subject.
15. This subject is a cultural subject.
16. All lessons and all methods used in this subject are clear and definite.
17. This subject is O. K.
18. I am willing to spend my time studying this subject.
19. This subject is not receiving its due in public high schools
20. This subject saves time.
21. This subject is not a bore.
22. This subject is a good pastime.
23. I don't believe this subject will do anybody any harm.
24. I am careless in my attitude toward this subject, but I would not like to see this attitude become general.
25. I haven't any definite like or dislike for this subject.
26. This subject will benefit only the brighter students.
27. My parents never had this subject; so I see no merit in it.

28. I could do very well without this subject.
29. Mediocre students never take this subject; so it should be eliminated from schools.
30. The minds of students are not kept active in this subject.
31. I am not interested in this subject.
32. This subject does not teach you to think.
33. This subject is very dry.
34. This subject reminds me of Shakespear's play--"Much Ado About Nothing."
35. I have no desire for this subject.
36. I have seen no value in this subject.
37. I would not advise anyone to take this subject.
38. This subject is based on "fogy" ideas.
39. This subject is a waste of time.
40. It is a punishment for anybody to take this subject.
41. This subject is disliked by all students.
42. I look forward to this subject with horror.
43. I detest this subject.
44. This subject is the most undesirable subject taught.
45. I hate this subject.

Figure 12: All Subjects Attitude Scale—Post Test

ATTITUDE TEST
POST

There are no right or wrong answers to these questions. People differ in their opinions on them. Just indicate your own opinion by blacking in with a #2 pencil the number on the answer sheet which corresponds most closely with your feelings. Leave no blanks. Please place answers on provided answer sheets.

1 = Agree, 2 = Disagree

1. I am "crazy" about this subject.
2. The very existence of humanity depends upon this subject.
3. If I had my way, I would compel everybody to study this subject.
4. This subject is one of the most useful subjects I know.
5. I believe this subject is the basic one for all high school courses.
6. This is one subject that all young Americans should know.
7. This subject fascinates me.

8. The merits of this subject far outweigh the defects.
9. This subject gives pupils the ability to interpret situations they will meet in life.
10. This subject will help pupils socially as well as intellectually.
11. This subject makes me efficient in school work.
12. There are more chances for development of high ideals in this subject.
13. This subject is interesting.
14. This subject teaches methodical reasoning.
15. This subject serves the needs of a large number of boys and girls.
16. All methods used in this subject have been thoroughly tested in the classroom by experienced teachers.
17. This subject has its merits and fills its purpose quite well.
18. Every year more students are taking this subject.
19. This subject aims mainly at power of execution or application.
20. This subject is not based on untried theories.
21. I think this subject is amusing.
22. This subject has its drawbacks, but I like it.
23. This subject might be worthwhile if it were taught right.
24. This subject doesn't worry me in the least.
25. My likes and dislikes for this subject balance one another.
26. This subject is all right, but I would not take any more of it.
27. No student should be concerned with the way this subject is taught.
28. To me this subject is more or less boring.
29. No definite results are evident in this subject.
30. This subject does not motivate the pupil to do better work.
31. This subject has numerous limitations and defects.
32. This subject interferes with developing.
33. This subject is dull.
34. This subject seems to be a necessary evil.
35. This subject does not hold my interest at all.
36. The average student gets nothing worth having out of this subject.
37. All of the material in this subject is very uninteresting.
38. This subject can't benefit me.
39. This subject has no place in modern world.
40. Nobody likes this subject.
41. This subject is more like a plague than a study.
42. This subject is all bunk.
43. No sane person would take this subject.
44. Words can't express my antagonism toward this subject.
45. This is the worst subject taught in school.

A multiple correlation matrix was run on students by age, sex, race, years of science study, years of mathematics study, achievement in chemistry, attitude toward science, and reading ability. The only correlation found above 0.5 was between years of mathematics study and years of science study. Hence, Hypotheses 1 and 2 were not accepted while hypothesis 3 was accepted.

In summary, the data indicate that students achieve more in chemistry, as measured by the ACS-NSTA Chemistry Test, and have a more positive attitude toward the study of chemistry in the experimental, individualized chemistry classes than in traditional chemistry classes used in this study. Further, the data also indicate that ninety percent of the time the results were not due to chance.

At a recent drive-in conference for the project, teachers were asked to evaluate the program. Several points seemed clear:

1. In general, teachers approved the overall design, but some individual teachers were not in agreement with some of the content in the units. Some did not like the quiz questions; others did not like the original system of evaluation; others had problems procuring the necessary laboratory materials; others pointed out gaps or the need for supplemental materials.
2. Teachers liked the freedom the program seems to provide for the students.
3. They liked the idea of being involved in the curriculum development process, providing input to use for modification of the program.
4. They considered the standard testing part of the program as necessary to the evaluation process.

In conclusion, it may be assumed that teachers are certain about the effectiveness of such a program. There seems to be enough evidence to indicate that students, because of all the pressures upon them and because they are accustomed, generally, to more structured direction while in school, will take a longer period of time to adjust to this new found freedom to assume increasing responsibility for their own learning. It is also clear that some students may not adjust at all. This is another way of saying the process of individualizing may require more than freedom and new responsibility for some students; it may require a personalized learning experience for the student that may take many forms that will require a teacher to modify his/her total teaching style. Depending on the teacher, this may or may not be possible.

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